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Stahlman et al.

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(54) **PUMP HAVING A BLEEDING VALVE**

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(52) **U.S. Cl.** **417/53**; 417/440; 417/534; 92/182; 92/183

(58) **Field of Search** 417/53, 440, 534; 92/182, 183

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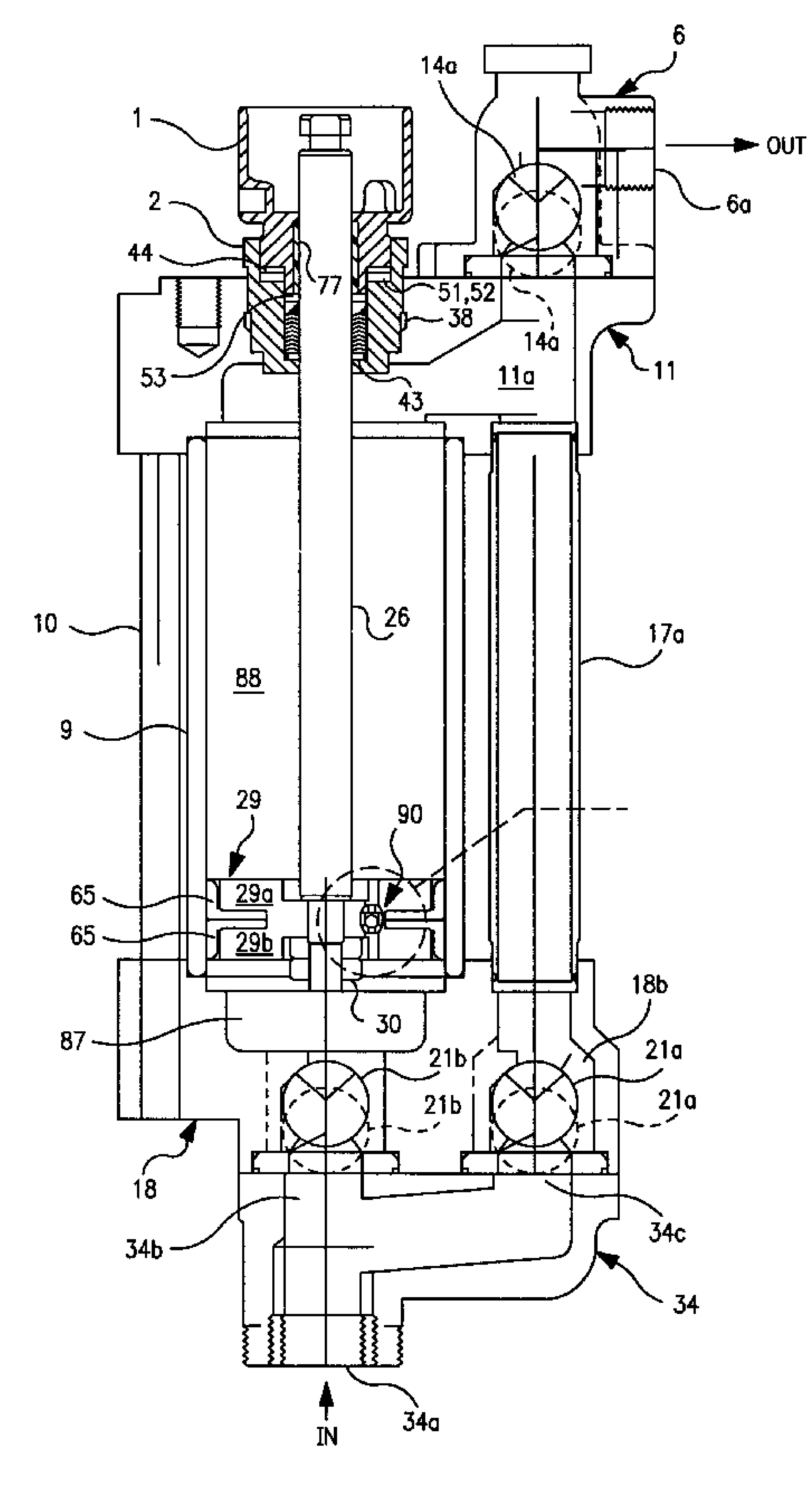
(57) **ABSTRACT**

A pump comprises a housing having a fluid inlet and a fluid outlet. A piston is mounted for reciprocating motion in first and second directions within the housing. The housing has first and second cavities on first and second sides of the piston, respectively. The first and second cavities are fluidly coupled to the fluid inlet and fluid outlet, so that fluid is pumped to the fluid outlet when the piston moves in either of the first and second directions. A bleed valve is coupled between the first and second cavities. The bleed valve has first and second closed states and an open state. The bleed valve changes from the first closed state through the open state to the second closed state when the piston moves in the first direction. The bleed valve changes from the second closed state through the open state to the first closed state when the piston moves in the second direction.

13 Claims, 5 Drawing Sheets



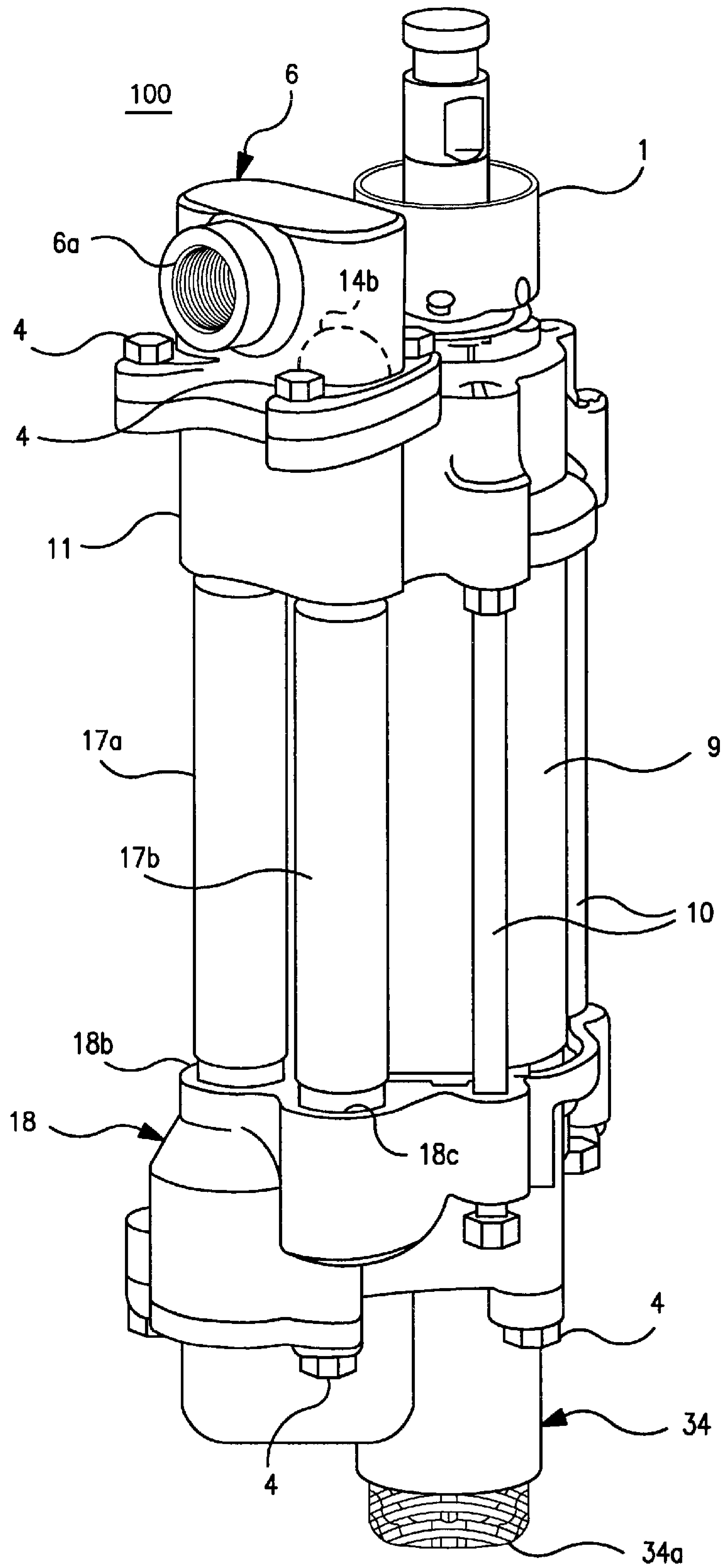


FIG. 1

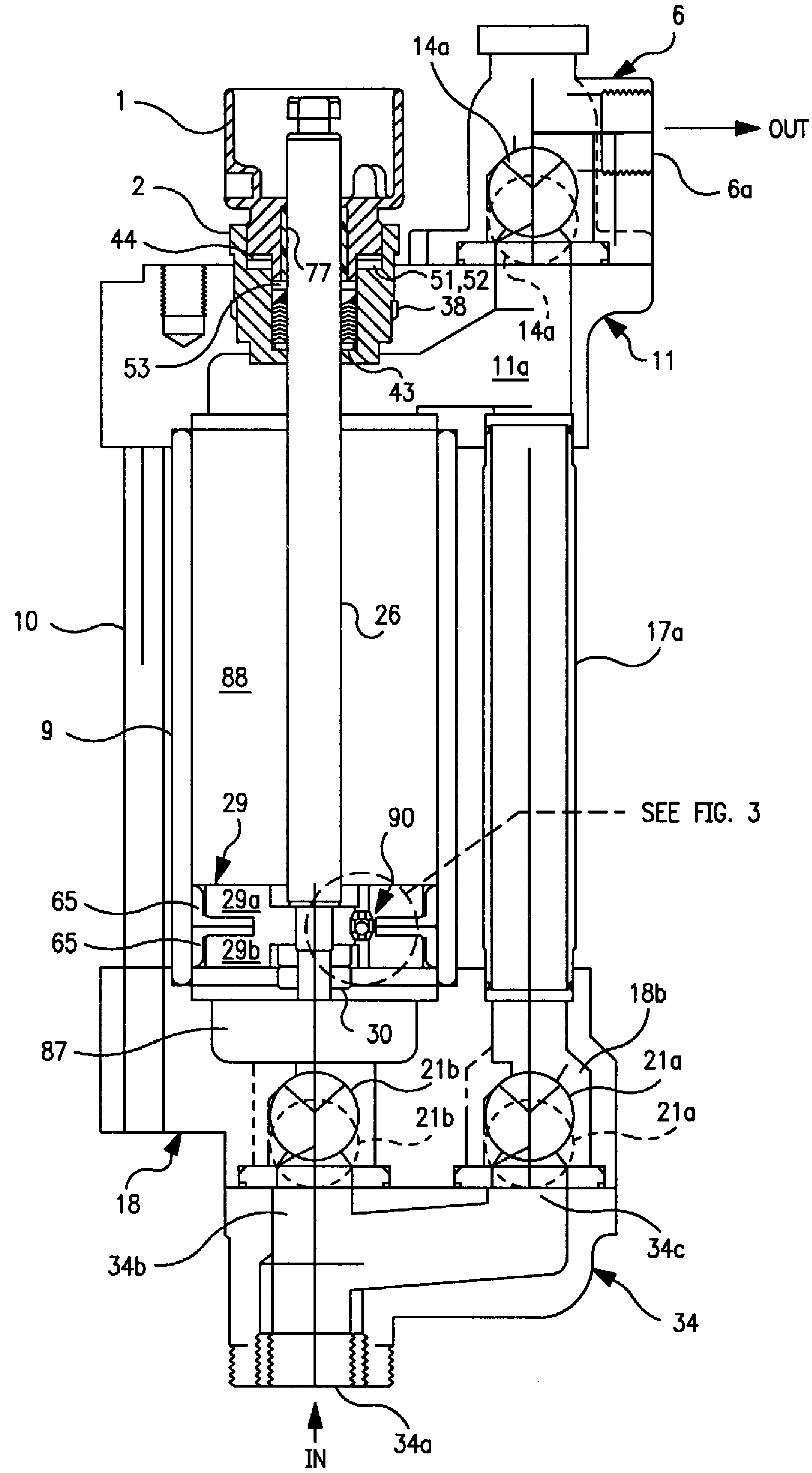

6
14a
OUT
1
6a
2
44
77
51,52
38
14a
53
43
11a
11
10
26
17a
88
9
29
90
SEE FIG. 3
65
29a
65
29b
18b
30
87
21b
21a
21b
21a
18
34b
34c
34
IN
34a

FIG. 2

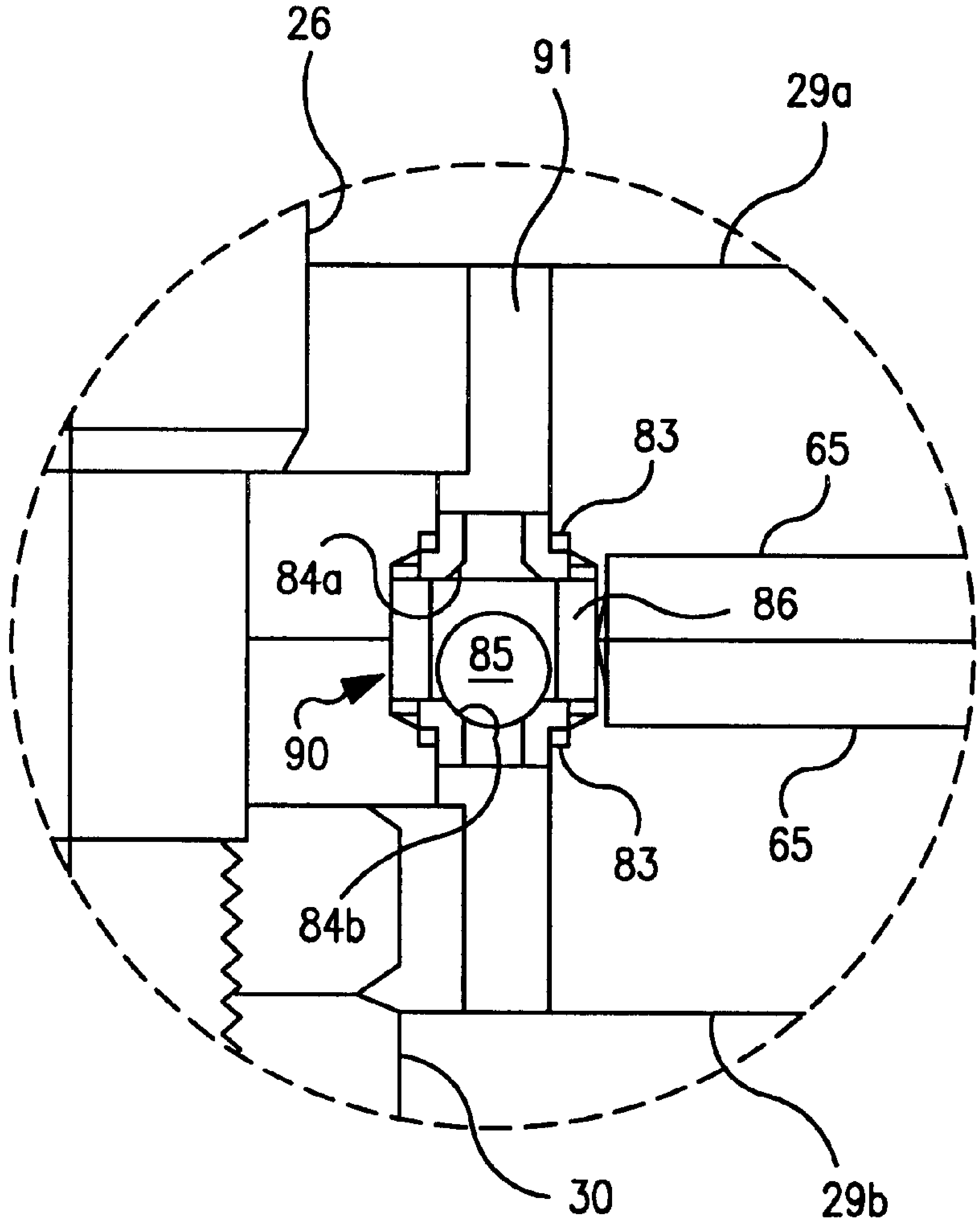


FIG. 3

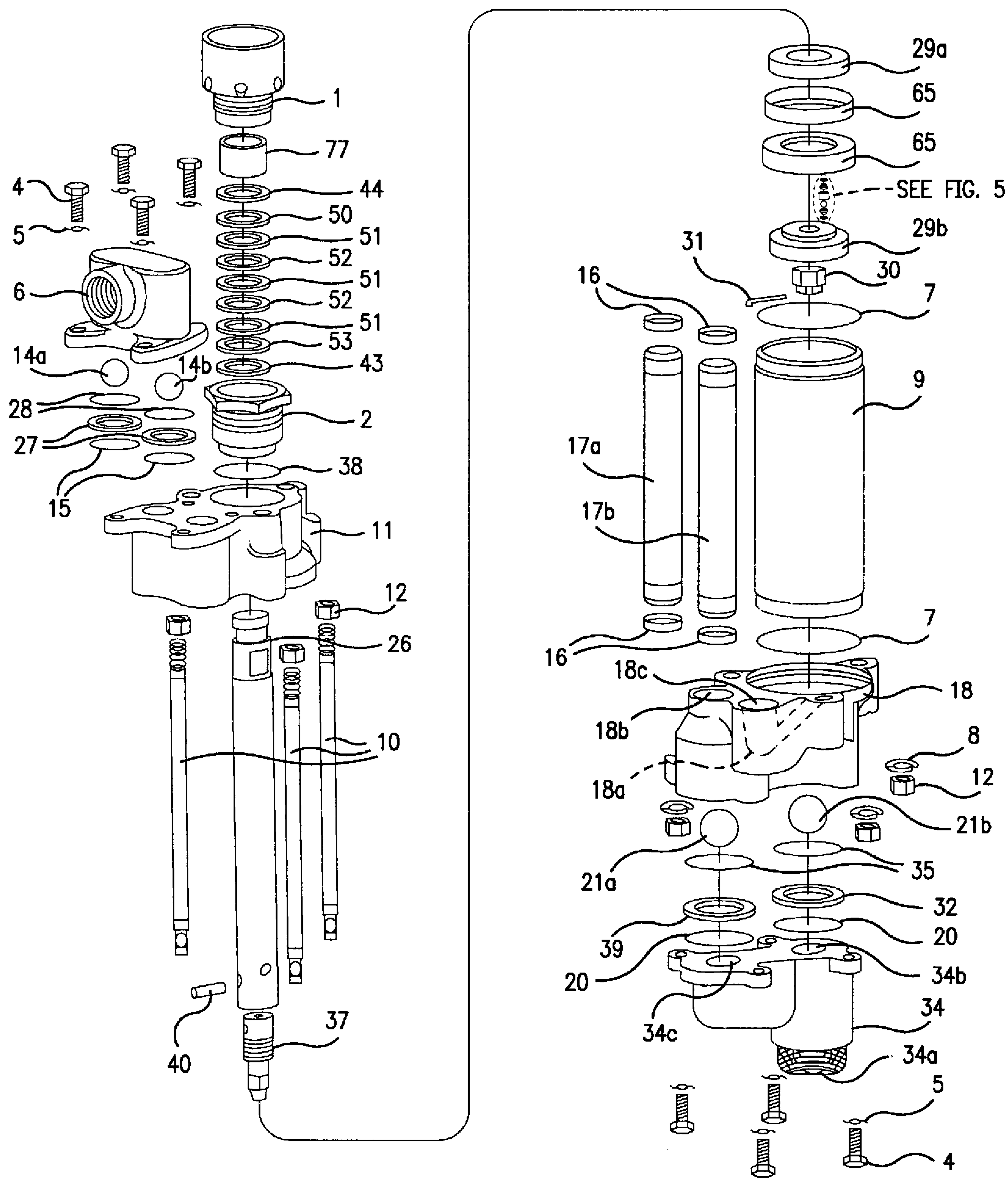

1
77
44
50
51
52
51
52
51
53
43
2
38
11
4
5
6
14a
14b
28
27
15
12
26
10
40
37
29a
65
65
SEE FIG. 5
29b
31
30
16
7
9
17a
17b
7
16
18c
18
18b
8
18a
12
21b
35
21a
32
20
39
34b
20
34
34c
34a
5
4

FIG. 4

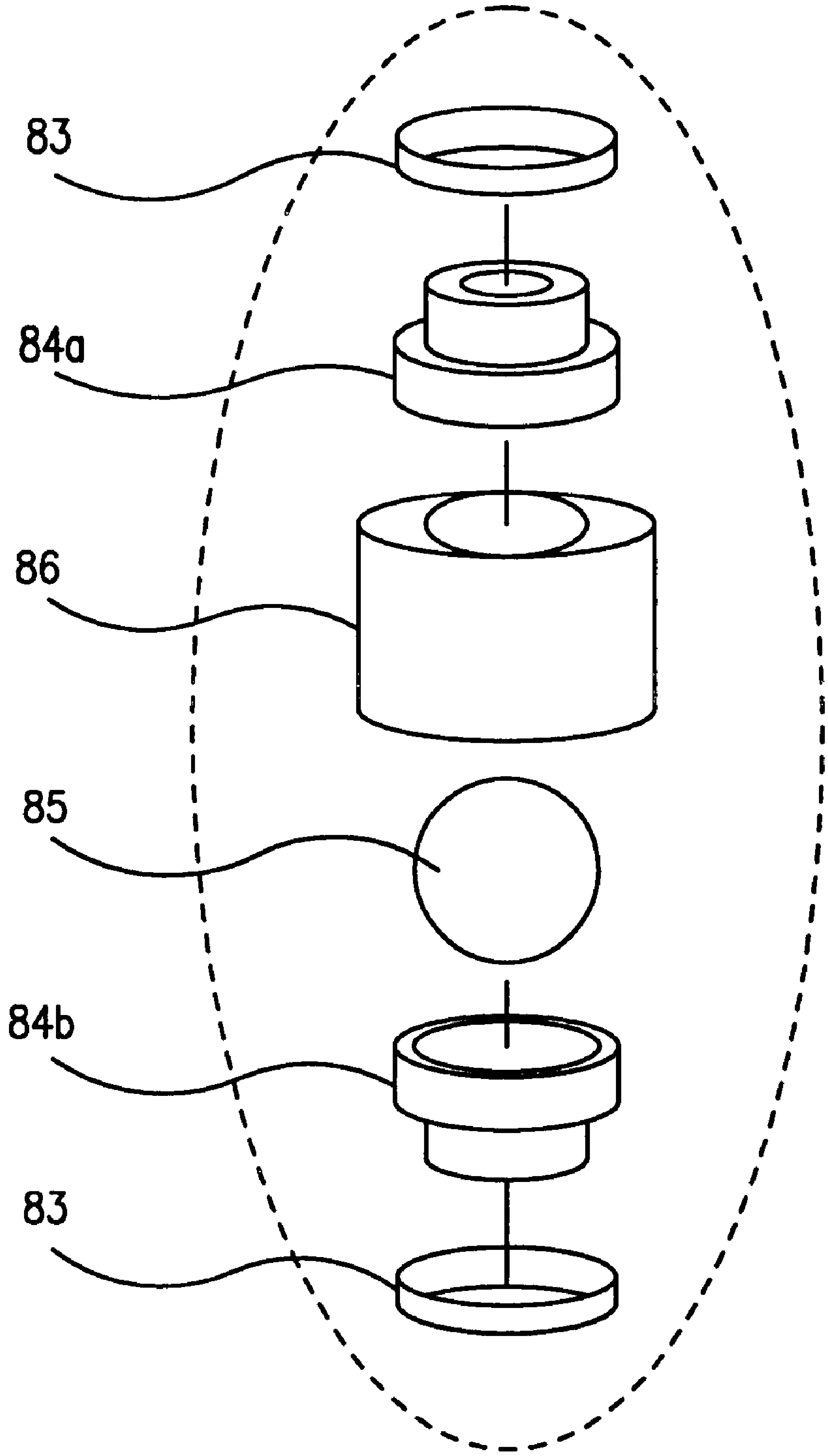


FIG. 5

PUMP HAVING A BLEEDING VALVE

DESCRIPTION OF THE RELATED ART

The present invention relates to the field of pumps, generally, and more specifically to pumps driven by a reciprocating piston.

FIELD OF THE INVENTION

Four-ball pumps have been used in spraying applications for many years, in such diverse applications as spraying furniture and automobiles. A typical four ball pump has a reciprocating piston, which may be pneumatically powered. Fluid is drawn up into the inlet and propelled from the outlet, both on the upstroke and downstroke of the piston. On the upstroke of the piston, fluid is drawn up beneath the piston, and fluid above the piston is propelled out of the fluid outlet. On the downstroke of the piston, fluid beneath the piston is forced into a first tube that is fluidly coupled to the fluid outlet, and a second tube coupled to the cavity above the piston. The fluid in the first tube is propelled out of the outlet. Meanwhile, a partial vacuum is formed on top of the piston, drawing the fluid from the second tube into the cavity above the top of the piston. This flow is regulated by four ball-type check valves.

The piston of a conventional four ball pump is connected to a pneumatic pressure source, even when no spray is required, and the fluid flow is cut off by closing the fluid outlet (for example, by closing a nozzle attached to the fluid outlet). When the fluid outlet is closed, fluid can no longer pass between the cavities above and below the piston, and the motion of the piston stops. This conserves pneumatically supplied power.

When the pump is first started up (also known as priming), air becomes trapped under the piston. Because the air rises above the liquid under the piston, the air cannot escape. Unlike liquids, air is compressible. When the pump transitions from the upstroke to the downstroke of the piston, the air beneath the piston is compressed, causing a pressure pulse. This change in the pressure at the fluid outlet causes an uneven finish in the article being sprayed.

In an attempt to eliminate the trapped air and reduce the pressure changes and uneven finish caused by the trapped air, others have located a small orifice in the piston, connecting the cavities above and below the piston. The trapped air below the piston can bleed through the hole, and escape through the cavity above the piston and the fluid outlet. Although this hole allows the trapped air to escape, it has not been a satisfactory solution. Because fluid can now pass between the cavities above and below the piston, the piston continues its reciprocating motion, even when the fluid outlet is closed. Thus, the pump continues to consume air power, even when not in use. Another problem is that particles forced through the small orifice can break down. For example, metallic particles in metallic paint break down, so that after several hours, the paint has a different appearance. Further, over time, the continuous flow through the orifice enlarges the hole, bypassing an increasing amount of fluid.

An improved pump is desired.

SUMMARY OF THE INVENTION

A pump comprises a housing having a fluid inlet and a fluid outlet. A piston is mounted for reciprocating motion in first and second directions within the housing. The housing has first and second cavities on first and second sides of the piston, respectively. The first and second cavities are fluidly coupled to the fluid inlet and fluid outlet, so that fluid is pumped to the fluid outlet when the piston moves in either of the first and second directions.

A bleed valve is coupled between the first and second cavities. The bleed valve has first and second closed states and an open state. The bleed valve changes from the first closed state through the open state to the second closed state when the piston moves in the first direction. The bleed valve changes from the second closed state through the open state to the first closed state when the piston moves in the second direction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric view of an exemplary pump according to the present invention.

FIG. **2** is a cross sectional view of the pump of FIG. **1**.

FIG. **3** is an enlarged view of a feature shown in FIG. **2**.

FIG. **4** is an exploded view of the pump shown in FIG. **1**.

FIG. **5** is an enlarged view of a feature shown in FIG. **4**.

DETAILED DESCRIPTION

FIGS. **1–5** show an exemplary pump **100** according to the present invention. FIGS. **1**, **2** and **4** show general features of the pump **100**. FIGS. **3** and **5** are enlarged views of a bleed valve **90** that is described in detail below.

The pump **100** has a housing. In the exemplary embodiment, the housing includes an upper body **11**, a lower body **18**, and an inlet body **34**, which may all be made of stainless steel or other suitably strong and corrosion resistant material. The upper body **11** and lower body **18** are connected to each other by three tie rods **10** and tie rod nuts **12**, which may be made of stainless steel, for example. The inlet body **34** is mounted to the lower body **18**, for example by bolts **4**. The upper body **11** and lower body **18** are also connected to each other by a piston tube **9** and two downtubes **17*a*** and **17*b***, which conduct fluid between the fluid inlet **34*a*** and upper body **11**. The downtubes **17*a*** and **17*b*** may be made of stainless steel, for example, and the piston tube **9** may be made of ceramic coated stainless steel or hard chrome plated stainless steel, for example.

The upper body **11** of the housing has a ball cap **6** with a fluid outlet **6*a*** attached thereto. The inlet body **34** of the housing has a fluid inlet **34*a***. The inlet body **34** has two outlet holes, **34*b*** and **34*c***. The lower body **18** has two main passages **18*a*** and **18*b*** through it. One passage **18*a*** (shown in phantom in FIG. **4**) connects the cavity **87** beneath the piston tube **9** to a mounting hole **18*c***, to which downtube **17*b*** is mounted. A passage **18*b*** connects the outlet hole **34*c*** of inlet body **34** to downtube **17*a***. Fluid from the inlet **34*a*** can either flow through passage **34*b*** beneath piston tube **9** or through passage **34*c*** and passage **18*b*** to downtube **17*a***, under control of check valves, as shown in FIG. **2** and described below. Fluid in cavity **87** beneath the piston tube **9** can flow through passage **18*a*** to downtube **17*b***.

A piston **29** is mounted for reciprocating motion in first and second directions (e.g., up and down) within the piston tube **9** of the housing. The exemplary piston **29** includes a pair of cylindrical followers **29*a*** and **29*b*** attached to the lower end of a pump rod **26** and movable within the tube **9**. The followers may be made of stainless steel or the like. The pump rod **26** may be made from hard stainless steel, either ceramic coated or hard chrome plated. The followers **29*a***, **29*b*** have a pair of cup packings **26**, to prevent leakage between the first cavity **87** below the piston **29** and the second cavity **88** above the piston. The cup packings **26** may be made from ultra high molecular weight polyethylene (UHMWPE), for example. The first cavity **87** and the second cavity **88** are fluidly coupled to the fluid inlet **34***a* and fluid outlet **6***a*, respectively, as described below, so that fluid is pumped to the fluid outlet when the piston **29** moves in either of the first (upward in FIG. **2**) and second (downward in FIG. **2**) directions.

The piston **29** is slidably supported at the top end by bushing **77** held in place between a solvent cup **1** and a gland nut **2**. The bushing **77** may be made of acetal or polyphenylene sulfide, or the like. Gland nut **2** may be made of stainless steel. A seal is provided between the solvent cup **1** and gland nut **2** by washers **44** and **50** and packing **51** and **52**. The washers **44** and **50** may be made from stainless steel, acetal, or polyphenylene sulfide, for example. The packing **51** and **52** may be, for example, glass filled Teflon, UHMWPE, leather, or the like. Within the gland nut **2**, a wave spring **43** and washer **53** bias the bushing **77**, to maintain its position during motion of the pump rod **26**. The spring **43** and washer **53** may be made from stainless steel, for example.

Fluid flow within the pump **100** is primarily controlled by four check valves. In the exemplary embodiment, the four check valves are ball valves **14***a*, **14***b*, **21***a* and **21***b*, but other types of check valves may be used. The ball valves **14***a*, **14***b*, **21***a* and **21***b* each include a stainless steel ball with a hardened stainless steel seat **27**, **32**.

The first check valve **21***b* is positioned between the fluid inlet **34***a* and the first cavity **87** beneath the piston **29**. During the upstroke of piston **29**, check valve **21***b* is open, permitting fluid to be drawn through passage **34***b* into the cavity **87**, by the partial vacuum in the cavity **87**. During the downstroke of the piston **29**, valve **21***b* is checked (as shown in phantom in FIG. **2**), preventing the fluid in cavity **87** from entering the fluid inlet **34***a*. During the downstroke, the fluid in cavity **87** flows through the passage **18***a* in lower body **18** directly to the downtube **17***b*.

The second check valve **21***a* fluidly connects the fluid inlet **34***a* and a downtube **17***a*. Downtube **17***a* is fluidly coupled by a passage **11***a* (FIG. **2**) within the upper body **11** to the second cavity **88** above the piston **29**. During the downstroke, fluid enters inlet **34***a* and passes though passage **34***c*, second check valve **21***a*, downtube **17***a* and passage **11***a* into cavity **88**. During the upstroke of the piston **29**, pressure in the second cavity **88** forces the second check valve **21***a* to the checked position (shown in phantom in FIG. **2**), so that fluid from the fluid inlet **34***a* cannot enter downtube **17***a*.

The third check valve **14***a* (FIGS. **2** and **4**) is fluidly coupled to the fluid outlet **6***a*, for transmitting fluid from the second cavity **88** through the fluid outlet when the piston **29** moves in the first (upward) direction. During the upstroke of piston **29**, the third check valve **14***a* is in the open position shown by solid lines in FIG. **2**; fluid flows from cavity **88** through **25** passage **11***a*, through valve **14***a*, and out through outlet **6***a*. During the downstroke of piston **29**, the third check valve **14***a* is in the checked position shown in phantom in FIG. **2** (because of the partial vacuum in the second cavity **88**), thus preventing backflow of any fluid from the fluid outlet into the valve **100**, and isolating downtube **17***a* from the fluid outlet.

The fourth check valve **14***b* is fluidly coupled to the fluid outlet **6***a*, for transmitting fluid from the first cavity **87** to the fluid outlet by way of downtube **17***b*, when the piston **29** moves in the second (downward) direction. Downtube **17***b* is fluidly connected to the first cavity **87** by way of passage **18***a*, without an intervening check valve. During the downstroke, fluid from the first cavity **87** flows directly through the passage **18***a* in lower body **18** to downtube **17***b*, up through the downtube **17***b*, through check valve **14***b* to the fluid outlet **6***a*. During the upstroke of the piston **29**, the fourth check valve **14***b* is checked (due to the partial vacuum in cavity **87**), preventing backflow of any fluid from the fluid outlet **6***a* into the valve **100**, and isolating downtube **17***b* (and the first cavity **87**) from the fluid outlet.

In summary, during the downstroke, the first check valve **21***b* is checked, the second check valve **21***a* is open, the third check valve **14***a* is checked, and the fourth check valve **14***b* is open. During the downstroke, fluid from the inlet **34***a* passes through passage **34***c*, valve **21***a*, downtube **17***a*, passage **11***a* into second cavity **88**, and fluid from cavity **87** passes through passage **18***a*, downtube **17***b*, valve **14***b*, and the outlet **6***a*. During the upstroke, the first check valve **21***b* is open, the second check valve **21***a* is checked, the third check valve **14***a* is open, and the fourth check valve **14***b* is checked. During the upstroke, fluid from the inlet **34***a* passes through passage **34***b* and valve **21***b* into cavity **87**, and fluid from cavity **88** passes through passage **11***a*, valve **14***a* and out of outlet **6***a*.

Additional conventional elements shown in FIG. **4** are not described in detail herein, including **0**-rings **7**, **15**, **20**, **28**, **35**, and **38**; ball valve seats **27**, **32**, and **39**; seals **16**; washers **5**, **8**, **44**, **50**, **53**; nuts **12** and **30**; cotter pin **31**; and roll pin **40**. The functions of these elements for joining the major components are understood by those of ordinary skill in the art.

According to an aspect of the invention, a bleed valve **90** (best seen in FIGS. **3** and **5**) is coupled between the first cavity **87** and the second cavity **88**. The bleed valve **90** has first and second closed states and an open state. The exemplary bleed valve **90** has a bleed passage **91** penetrating the piston **29**. The bleed passage **91** has a first valve seat **84***a* and a second valve seat **84***b* with a ball **85** in between the seats. The ball **85** and seats **84***a*, **84***b* may be made from, for example, tungsten carbide. The ball **85** seats in the first valve seat **84***a* when the piston **29** moves in the first (downward) direction and seats in the second valve seat **84***b* when the piston **29** moves in the second (upward) direction. Bleed valve **90** also includes a spacer **86** (which may be made from stainless steel) separating the seats **84***a* and **84***b* and a pair of gaskets **83**, which may be nylon, for sealing the bleed valve.

When the ball **85** is seated in valve seat **84***b*, valve **90** is in the first closed state. When the ball **85** is seated in valve seat **84***a*, valve **90** is in the second closed state. When the ball is not seated in either seat **84***a* or seat **84***b*, the valve **90** is in the open state. While the bleed valve **90** is in the open state, air can escape from the first cavity **87** beneath the piston **29**. The bleed valve **90** changes from the first closed state (in seat **84***b*) through the open state to the second closed state (in seat **84***a*) when the piston **29** moves in the first direction (downward). The bleed valve **90** changes from the second closed state (in seat **84***a*) through the open state to the first closed state (in seat **84***b*) when the piston **29** moves in the second direction (upward).

As a result, the bleed valve **90** enters the open state for a brief period shortly after a change in direction of the piston **29**. More specifically, when the piston **29** changes from the upstroke to the downstroke, the ball **85** moves from seat **84***b* to seat **84***a*, allowing a small quantity of air to bleed out of cavity **87** while the ball **85** is in between the seats. After the piston **29** has progressed through about ten strokes, most or all of the air is bled out of the cavity **87**. By eliminating the air from cavity **87**, pressure pulses are eliminated. Thus, the exemplary pump **100** ensures even spraying and an even finish on any workpiece. Similarly, if the fluid source (e.g., a bucket of paint, not shown) that provides fluid to the fluid inlet **34***a* is changed, any air that enters cavity **87** is bled out within about ten strokes of the piston **29**.

An additional advantage of the bleed valve **90** is that the pump **100** automatically shuts off when the fluid outlet **6***a* is closed. For example, a spray nozzle (not shown) may be attached to the fluid outlet **6***a*. When the nozzle is closed, the fluid outlet **6***a* prevents egress of fluid through either the third ball valve **14***a* or the fourth ball valve **14***b*, which both become checked, thus preventing egress of fluid through downtube **17***a* or **17***b*.

For example, if the piston **29** is entering its upstroke, as shown in FIG. **2**, then the bleed valve ball **85** is seated in seat **84***b* as shown in FIG. **3**. Thus, no fluid can pass directly between the first cavity **87** and the second cavity **88**. Because fluid is incompressible, the piston **29** is effectively prevented from moving upward, because the closed nozzle (not shown) checks valve **14***a* and prevents fluid from leaving the fluid outlet **6***a*. The pressure in the second cavity **88** also causes the second valve **21***a* to become checked, preventing fluid from leaving via the fluid inlet.

Similarly, if the nozzle is closed while the piston **29** is beginning its downstroke, the ball **85** of the bleed valve **90** is seated in the upper seat **84***a*, preventing fluid flow between the first cavity **87** and the second cavity **88**. The incompressible fluid in the first cavity **87** closes the first check valve **21***b*, preventing egress of fluid through the inlet **34***a*. The nozzle prevents fluid flow through the fourth check valve **14***b*, the downtube **17***b*, or passage **18***a*. Thus, the incompressible fluid in the first cavity cannot escape, and the motion of the piston **29** stops.

Because the piston **29** can neither move up or down, the pump **100** essentially shuts down. Because the piston **29** is driven by an air source (not shown), when the piston stops moving, the pump stops consuming air, but is still pressurized.

Other embodiments of the invention are contemplated. For example, in one variation of the pump (not shown), the upper and lower body may be joined by fewer or more than three tie rods. In another variation of the pump (not shown), the housing may be formed as a solid casting or molded body in left and right halves (the piston tube **9** and downtubes **17***a* and **17***b* may be integrally formed as part of the housing or may be separate tubes fitting inside the housing). In some embodiments of the invention, the housing of the pump may be divided into fewer or more sections than are shown in FIG. **4**. Further, although exemplary materials are described above, one of ordinary skill in the art may substitute equivalent materials without changing the function of the pump described above.

Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claim should be construed broadly, to include other variants and embodiments of the invention which may be made by those skilled in the art without departing from the scope and range of equivalents of the invention.

What is claimed is:

1. A pump, comprising:

a housing having a fluid inlet and a fluid outlet;

a piston mounted for reciprocating motion in first and second directions within the housing, the housing having first and second cavities on first and second sides of the piston, respectively, the first and second cavities being fluidly coupled to the fluid inlet and fluid outlet so that fluid is pumped to the fluid outlet when the piston moves in either of the first and second directions;

a bleed valve coupled between the first and second cavities and having first and second closed states and an open state, the bleed valve changing from the first closed state through the open state to the second closed state when the piston moves in the first direction, the bleed valve changing from the second closed state through the open state to the first closed state when the piston moves in the second direction.

2. The pump of claim **1**, wherein the bleed valve includes:

a bleed passage penetrating the piston, the bleed passage having first and second valve seats, and

a ball that seats in the first valve seat when the piston moves in the first direction and seats in the second valve seat when the piston moves in the second direction.

3. The pump of claim **2**, wherein the bleed valve is in the open state, permitting air to escape from the first cavity, while the ball is between the first valve seat and the second valve seat.

4. The pump of claim **1**, wherein the first cavity is beneath the piston, and the second cavity is above the piston.

5. The pump of claim **1**, further comprising:

a first check valve fluidly coupled to the fluid inlet, for admitting fluid into the first cavity when the piston moves in the first direction;

a second check valve fluidly coupled to the fluid inlet, for admitting fluid into the second cavity when the piston moves in the second direction;

a third check valve fluidly coupled to the fluid outlet, for transmitting fluid from the second cavity through the fluid outlet when the piston moves in the first direction; and

a fourth check valve fluidly coupled to the fluid outlet, for transmitting fluid from the first cavity through the fluid outlet when the piston moves in the second direction.

6. The pump of claim **5**, wherein the first, second, third and fourth check valves are ball valves.

7. A pump, comprising:

a housing having a fluid inlet and a fluid outlet;

a piston mounted for reciprocal motion within the housing, the housing having first and second cavities on first and second sides thereof, respectively;

a first check valve fluidly coupled to the fluid inlet, for admitting fluid into the first cavity when the piston moves in a first direction;

a second check valve fluidly coupled to the fluid inlet, for admitting fluid into the second cavity when the piston moves in a second direction;

a third check valve fluidly coupled to the fluid outlet, for transmitting fluid from the second cavity through the fluid outlet when the piston moves in the first direction;

a fourth check valve fluidly coupled to the fluid outlet, for transmitting fluid from the first cavity through the fluid outlet when the piston moves in the second direction; and

a bleed valve coupled between the first and second cavities and having first and second closed states and an open state, the bleed valve changing from the first closed state through the open state to the second closed state when the piston moves in the first direction, the bleed valve changing from the second closed state through the open state to the first closed state when the piston moves in the second direction.

8. A method of operating a pump having a housing, a fluid inlet, a fluid outlet, and a piston mounted for reciprocating motion in first and second directions within the housing, the housing having first and second cavities on first and second sides of the piston, respectively, the first and second cavities being fluidly coupled to the fluid inlet and fluid outlet, comprising the steps of:

pumping fluid to the fluid outlet when the piston moves in either of the first and second directions;

bleeding fluid through a bleed valve coupled between the first and second cavities while the bleed valve is in an open state, the bleed valve having first and second closed states;

changing the bleed valve from the first closed state through the open state to the second closed state when the piston moves in the first direction; and

changing the bleed valve from the second closed state through the open state to the first closed state when the piston moves in the second direction.

9. The method of claim 8, wherein the bleed valve includes:

a bleed passage penetrating the piston, the bleed passage having first and second valve seats, and

a ball that seats in the first valve seat when the piston moves in the first direction and seats in the second valve seat when the piston moves in the second direction.

10. The method of claim 9, wherein the bleed valve is in the open state, permitting air to escape from the first cavity, while the ball is between the first valve seat and the second valve seat.

11. The method of claim 8, wherein the first cavity is beneath the piston, and the second cavity is above the piston.

12. The method of claim 8, further comprising:

admitting fluid into the first cavity via a first check valve fluidly coupled to the fluid inlet, when the piston moves in the first direction;

admitting fluid into the second cavity via a second check valve fluidly coupled to the fluid inlet, when the piston moves in the second direction;

transmitting fluid from the second cavity through the fluid outlet via a third check valve fluidly coupled to the fluid outlet, when the piston moves in the first direction; and

transmitting fluid from the first cavity through the fluid outlet via a fourth check valve fluidly coupled to the fluid outlet, when the piston moves in the second direction.

13. The method of claim 12, wherein the first, second, third and fourth check valves are ball valves.

* * * * *